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ABSTRACT

As part of a larger comparison of the school-to-work transition in Switzerland and Great Britain, instruction in mathematics, science, and practical subjects (industrial arts and home economics) in the two countries was compared by two methods: site visits to English and Swiss schools by teams of English teachers and inspectors and analyses of the performance of samples of English and Swiss students on the International Assessment of Educational Progress (IAEP). Of the English and Swiss pupils selected on a representative basis, 47% and 80% participated, respectively. The Swiss students scored significantly higher on the IAEP than the British students did. Although some English students met standards as high as those observed in Switzerland, Swiss students generally appeared to be 1-2 years ahead of their English counterparts. The observed differences between English and Swiss students' levels of achievement were attributed partly to differences in the teaching styles and syllabus content observed in the two countries and partly to the excellence of Swiss primary school teachers. Emphasis on pupils' active involvement in the learning process was greater in Switzerland. (Contains 78 footnotes. Appended is information on a Swiss experiment in comprehensive schooling.) (MN)

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NATIONAL INSTITUTE OF ECONOMIC AND SOCIAL RESEARCH

SCHOOLING AS PREPARATION FOR LIFE AND WORK IN SWITZERLAND AND BRITAIN

Helvia Bierhoff and SJ Prais

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by
Helvia Bierhoff
and SJ Prais

Discussion Paper no. 75
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This paper forms part of a wider comparison of the transition from school to work in Switzerland and Britain; the full report - of which this is intended to be the third chapter - will also cover vocational guidance and vocational training. The Institute is grateful to the Leverhulme Trust and the Gatsby Charitable Foundation which have made this project possible. The project has benefited from the co-operation of very many generous persons - too numerous to be mentioned here - in schools and educational authorities in both countries, particularly in Zürich and Barking & Dagenham, and from those responsible for vocational training in engineering and other occupations in both countries. Corrections and suggestions for improvement to the present draft would be welcomed by the authors.

SCHOOLING AS PREPARATION FOR LIFE AND WORK IN SWITZERLAND AND BRITAIN

by Helvia Bierhoff and SJ Prais

SCHOOL ATTAINMENTS AND SCHOOL ORGANISATION

The attainments of the Swiss schooling system attracted international admiration following Switzerland's participation for the first time in 1991 in international tests in mathematics and science set to large representative samples of 13 year-old pupils. These tests - known as the International Assessment of Educational Progress (IAEP) - were taken by pupils in some twenty countries under the sponsorship of the US Department of Education (they were carried out by the Education Testing Service of Princeton, New Jersey, an organisation with much experience of testing in the US). Broadly speaking, Switzerland obtained the highest *average* scores in mathematics; and the scores attained by the *lowest tenth* of all Swiss pupils were very far ahead of the corresponding proportion of pupils in Britain and of all other countries in that survey.[1] Tests in science showed Swiss pupils at a similar advantage. Swiss methods of schooling, it seems, have led to both higher and more even attainments than in Britain. Because of the now widely acknowledged need to improve schooling attainments in Britain particularly of pupils of average or below-average ability, the finding for low-attainers makes Switzerland of very great interest here.

Switzerland has long been blessed with a number of educational thinkers who have acquired international renown: Rousseau, Pestalozzi and Froebel were reformers active in the eighteenth and nineteenth centuries (Froebel worked for a decade with Pestalozzi before returning to his native Germany; his writings subsequently had great influence in German-speaking Switzerland). In the twentieth century, Binet and Piaget carried out fundamental work on the measurement and development of children's intelligence and capabilities. Pestalozzi's emphasis two hundred years ago on fostering arithmetical attainments at an early age remains of interest today in the light of the recent IAEP survey (just mentioned) showing Swiss pupils' outstanding performance in mathematics and, as we shall see

[1] Certain exceptions to this broad summary may be footnoted. China recorded higher scores, but only half of all pupils there - presumably the more academic half - are at school at age 13. Korea and Taiwan recorded very slightly higher average scores than Switzerland; but for the lowest tenth of pupils Switzerland was still far ahead. Results recorded for such newly developing countries in international tests are impressive; but the cultural gap makes it difficult to draw policy conclusions relevant to Britain.

below, particularly in arithmetic.[2] The ideals and reforms of the Swiss educationists may be said, in a word, to be directed towards giving teachers a better understanding of a child's early intellectual and emotional development, promoting a closer teacher-pupil relationship, and organising teaching so that it takes place - as near as may be possible - in a family atmosphere.[3] Reliance on rote learning in large classes (50-100 pupils per teacher were often mentioned in descriptions of schooling in the nineteenth century) was to be replaced by more individual 'child-centred' tasks in which children were encouraged to discover things for themselves but, it needs to be emphasised because of a subsequent change in emphasis in British teaching practice, *under the guidance of their teacher*. The new methods were of course more expensive; nevertheless, they gradually influenced teaching methods in all countries. Remarkably enough, they seem to have been taken further in Britain (especially following the Plowden reforms of 1967) than in Switzerland; it is as if the greater native caution of the Swiss, or their better feeling for a *balance* of teaching approaches, has avoided the excesses of modern approaches which have recently caused concern in Britain. In particular, the need for teachers actively to guide pupils' learning (emphasized by both Pestalozzi and Froebel) still remains clearly evident in Swiss classrooms, whereas in England that approach has been replaced to a great extent by methods in which the teacher spreads his time - inevitably thinly - amongst his many individual charges.[4]

[2] K Silber, *Pestalozzi: The Man and his Work* (Routledge & Kegan Paul, London, 1960); Pestalozzi's methods of teaching arithmetic through contextual examples of carefully graded difficulty were better known in England - at least in certain parts - in the nineteenth century than today as a result of visits at that time on behalf of the educational authorities by JP Kay-Shuttleworth to Switzerland and other Continental countries (see his *Four Periods of Public Education*, Longmans, 1862). A school primer in mathematics based on Pestalozzi's principles was issued in English under the stimulus of Kay-Shuttleworth in 1844 with the title *Exercises in Arithmetic for Elementary Schools after the Methods of Pestalozzi*, by J W Parker; it formed part of the teacher training programme at Battersea Teachers' Training College in subsequent decades.

[3] On the objective of unifying family and school life, as conceived by Pestalozzi and his followers, see the remarks of R Lassahn in the proceedings of the 38th *Gemeiner Kongress* (1988, p. 69).

[4] The way Froebel's ideas influenced teaching in Britain is explained by J Leibschner, *The Foundations of Progressive Education* (Lutterworth, Cambridge 1991), p.154 *et seq.* A brief and fascinating account of the adoption of progressive methods in English primary schools has recently been made available by Professor R Alexander, *Innocence and Experience: Reconstructing Primary Education* (Trentham, 1994).

Our visits to Swiss schools in 1992-4 permitted us to observe directly the differences in pupils' attainments recorded in the IAEP tests, and to attempt to identify contributory factors. Our visits were carried out in the company of experienced English school inspectors, headteachers and senior teachers from English schools; there have also been reciprocal visits by Swiss teachers and educationists. It goes without saying that not everything that is different abroad is necessarily better, nor necessarily transferable to other countries; but it remains worth recording those differences in schooling organisation and in teaching methods that appear to bear most significantly on pupils' attainments, and to assess which of them might provide pointers for improvements that could be applied here.

The Swiss educational authorities helped in selecting both below-average and above-average schools (in terms of pupils' social background, family problems, immigrant proportions) so that an impression of the variability of schooling could be obtained. The schools visited were mainly in the city and Canton of Zürich - a world-renowned financial, commercial and industrial centre in the German-speaking part of the country (population of the city, 0.3m.; of the Canton, 1.2m.); other schools were visited in Bern and St Gallen (also German-speaking). About three-quarters of all Swiss inhabitants have German as their mother-tongue; within the limitations of this study, it seemed better not to complicate the picture by including schools from the French and Italian sections of the country.

About fifty lessons in over a dozen schools were observed. Discussions were also held with educational specialists, teacher training colleges, career guidance specialists, and training officers in large firms; the broad object was to obtain a view of the foundation provided during secondary schooling for subsequent vocational training and employment. These discussions also covered changes in schooling that might be desirable in the light of current developments in technology and in international competition.

Britain's greatest shortfall in qualified employees is at the craft level. Vocational training at that level for many occupations requires that the school-leaver has solid foundations in subjects such as mathematics, science and practical subjects. It is on these subjects that we focused our visits. We also focused on pupils in the lower half of the academic attainment-range; in the past these young people could take up unskilled and semi-skilled jobs, but increasing automation of production has meant that the number of such jobs have gradually diminished. The long-standing concern to raise the attainments of below-average school-leavers in Britain has become increas-

ingly pressing as a result of these technological trends; it was the teaching and attainments of such pupils that consequently engaged most of our concern on our visits abroad.[5]

Structure of schooling

Before comparing school-leaving standards, it is necessary to outline some basic structural features of the Swiss schooling system. Control of schooling in Switzerland is devolved to grass-root levels to a surprising degree: each of the 26 Cantons prides itself on its own educational legislation, and many Cantons require plebiscites on detailed decisions at the level of the school-district. Among such decisions are, for example, the election by popular vote of individual teachers in local school-districts to their position for six years at a time, and the introduction of experimental comprehensive schools. While there is much detailed variation among Cantons, many central features of the schooling system of Zurich can be regarded for the purpose of the present enquiry as indicative of the German-speaking areas of Switzerland.

Primary schools in Switzerland cover the full ability-range without streaming, as is equally usual in England. Pupils enter primary school in Zurich at the beginning of the school-year after the age of six and a quarter (following a school-readiness appraisal, if required); they attend primary school for six years that is, till age 12 (a year later than in England). They then transfer to one of four main types of secondary school: *Oberschulen*, which now cater for about the lowest 5 per cent of pupils (apart from pupils in special schools; *Oberschulen* previously catered for the lowest 15 per cent and are now being phased out); *Realschulen*, which cater for the next 30-35 per cent; *Sekundarschulen*, which cater for the next 45-50 per cent; and *Gymnasien* which cater for approximately the top 10 per cent (in addition a variety of special schools and special classes cater for children with special educational needs).[6] There are further opportunities to transfer to a *Gymnasium* after the second and third years at *Sekundarschule* (about a third of those leaving *Gymnasium* are

[5] For some historical background see SJP's Keynes Lecture to the British Academy in its *Proceedings*, 1993.

[6] Special classes and special schools cater for a slightly higher proportion of all pupils than in Britain, say 3-4 rather than 1-2 per cent. This difference between the two countries is quantitatively small, at only half a child per class on average; nevertheless, the difference is worth noting as one of the ways in which the task of the teacher in the majority of schools is made more manageable in Switzerland.

late-entrants of this type).[7] Compulsory schooling normally ends at age 15; but if a pupil has entered late, or repeated a year, he is required to stay for an additional year to complete the normal three years of obligatory secondary schooling.

Entry to obligatory schooling is thus some 18 months later than in England (where attendance usually begins in the *term* before a child reaches his fifth birthday - though many enter at the beginning of the previous school *year*); wealthy as Switzerland is, obligatory full-time schooling extends for only nine years ending at age 15, whereas in England it extends for eleven years ending at age 16.[8] In practice, however, almost all Swiss children attend kindergarten on a part-time basis, (three hours a day) for two years before obligatory schooling, that is, at ages 4-6; the difference between the countries in length of *actual* attendance is thus not quite as great as it may at first seem.

Our visiting teams of English teachers and inspectors frequently commented on the friendlier atmosphere and evident absence of tension (or 'antagonism') between pupils and teachers in Swiss classrooms; this better social atmosphere contributed to better learning and is an integral objective of Pestalozzian schooling. The following general organisational factors seem relevant. Secondary schools in Switzerland are considerably smaller than in England, with 250-500 pupils rather than the thousand or so typical of English comprehensive secondary schools; there is consequently a more intimate atmosphere. Class sizes are smaller, but only slightly: averages of 18 pupils in Switzerland and 22 pupils in England were recorded by the IAEP survey. Some of the current difference in class sizes is due to fluctuations in the birth-rate. The fall in the Swiss birth-rate in the past generation was rather sharper than in Britain (a fall in 1970-85 of 25 per cent in Switzerland compared with 15 per cent in Britain) and was followed by a sharper rise (12 per cent in 1985-90 in Swit-

[7] Pupils who transfer after the third year (class 9) at *Sekundarschule* have to repeat the ninth class at the *Gymnasium*. There is also the possibility for pupils to transfer to the third class of the *Sekundarschule* after completing the third class at the *Realschule*, ie to repeat the third class of secondary school at a higher-level school; this possibility is rarely taken up.

[8] As said, the account given here relates to Zürich; among the more significant variations in other Cantons, from an English point of view, is age of entry to obligatory schooling. In some Cantons (eg Grisons) it is a year later than in Zürich, and thus over two years later than in England. Nevertheless, the final outcomes for pupils' attainments in all the areas distinguished in the IAEP analyses are significantly higher than in England (v. fns. 15 and 38 below).

zerland compared with 6 per cent in Britain); a greater rise in class-sizes is now expected in Switzerland.

Probably of most importance in determining classroom atmosphere is the greater role of the form-teacher in the Swiss pupil's life. The Swiss form-teacher in *Realschulen* teaches the majority of subjects and takes the same group of pupils for three years at a time, that is, throughout compulsory secondary schooling from age 12 to 15. In *Sekundarschulen* there are two main teachers, one for arts and another for sciences (including mathematics), and both take the same group of pupils for three years (other details are footnoted).[9] The result is that the Swiss form-teacher knows the strengths and weaknesses of his individual pupils far better than usually possible for an English form-teacher (or for the pastoral tutor who has such responsibilities delegated to him in English secondary schools). The Swiss form-teacher is able to notice a pupil's problems at an earlier stage, can deal better with them on an individual basis, and can organise his class - in terms of seating arrangements and the distribution of his attention - so that the class as a whole advances with fewer distractions (we return to these aspects later in this paper when we discuss teaching styles).

The closer understanding of pupils developed by a Swiss form-teacher, as a result both of teaching more subjects and of teaching the same group of pupils for three years, is particularly important for *Realschule* pupils. A greater proportion of such pupils come from problem families; as teachers frequently told us, such pupils particularly benefit in their social adjustment and cognitive development from the additional support a Swiss form-teacher can give them because of the better insight he develops into their individual problems and latent capabilities.

While our main concern in this paper is with pupils' cognitive attainments, it deserves adding that Swiss teachers place much emphasis on pupils' development as responsible social beings. Through classroom discussion and activities involving 'role-play' they aim to promote the amicable resolution of conflict situations, and the democratic acceptance of classroom rules to improve the learning environment. As part of what is called *Menschenbildung*, perhaps translatable as 'learning to become a civilised human being', the Zürich curriculum-document explicitly lists among the duties of a school: encourage of pupils' willingness to accept social responsibility in a

[9] In both these school-types specialist teachers may take music, gymnastics, and textile work. Only in *Gymnasien* are subject-specialists employed, as familiar in England.

democratic framework; promote discussion to encourage mutual understanding; encourage recognition of the value of a transmitted common tradition and spiritual heritage, together with an open acceptance of other cultures; promote the use of leisure time for reflection and self-motivation to understand and help others.[10] Taken by themselves these phrases may seem to over-emphasize aspects that are taken for granted everywhere; our visits left us in little doubt that the promotion of such values at schools was taken further in Swiss than in English schools, and that it was advantageous to do so.

To some politically-sensitive readers, the allocation of pupils to various levels of secondary schooling on the basis of their attainments at primary school carries an old-fashioned and politically disreputable flavour: 'it can be viewed as an elitist practice and contrary to democratic principles', as that side of the argument was expressed in a recent educational reference book.[11] Nevertheless, it seems agreed on all sides that there is a dilemma here, in that the variability of pupils' attainments and interests increases with age, and teaching and learning in classes of widely-dispersed attainments are difficult. The issue is thus not *whether* schooling should diversify at older ages, but rather: at what ages, and in what ways should schooling diversify so that young people of different abilities and of different interests are best catered for? From an objective and scientific point of view, given the extraordinary success of the Swiss economy, our need in this study is to understand the degree of success of pupils' attainments under the Swiss schooling system, and to ask which of its structural features can be considered as contributing to its success; none of this vitiates any decision as to the political desirability or undesirability of various types of selective secondary schooling.

[10] *Lehrplan für die Volksschule des Kantons Zürich*, 1991, pp. 3-5.

[11] *The International Encylopedia of Teaching and Teacher Education* (ed. (MJ Dunkin), Pergamon, 1987, p.225 (article by Calfee and Piotkowski). The OECD's series of *Reviews of National Policies for Education* reported for the first time on *Switzerland* in 1991 (English edn), with similar critical - sometimes amusing - remarks. The Swiss secondary schooling system was written off as 'archaic' (p.26), without consideration of its remarkable achievements. 'It is well known that mountain peoples are concrete and practical and do not like vague concepts or too much talk. Above all, they are inclined to action: not precipitate but thought out, always moving cautiously and with a margin of safety' (p.55). The chief *Rapporteur* for the OECD *Review* was a French industrial sociologist, JJ Silvestre (of Aix-en-Provence). It is not obvious to the present writers that international tax-payers' money is well spent on such cursory exercises.

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In view of the widespread reliance on comprehensive secondary schools in Britain, and moves towards such schools in other countries, it is of interest that in the past 15-20 years a few comprehensive schools (called AVO schools) have been established on an experimental basis in certain school-districts in the Canton of Zürich with the aim of catering more flexibly for pupils' individual strengths and weaknesses, and improving social cohesion. These schools are closer to Britain's earlier (1970s) multi-lateral schools than to its current integrated comprehensive mixed-ability schools; they cater for all secondary school pupils in the relevant school-districts apart from those going to *Gymnasien* and special schools, that is, for about 80-85 per cent of the age-group. Pupils at these AVO schools are divided into two streams, a 'basic level' and an 'extended level', more or less parallel to the *Realschule* and *Sekundarschule*. This division applies to classes for most subjects; but in mathematics and the first foreign language (usually French), pupils are set into three attainment groups, not necessarily the same for the two subjects.[12] Only about a tenth of all secondary pupils in the Canton of Zurich go to these experimental schools.

There is as yet no consensus about the academic success of this experiment. The Appendix summarises the results of comparisons carried out by the Zürich Education Department of pupils' mathematical attainments under the AVO experimental comprehensive system and the traditional selective systems; these comparisons suggested a lowering of attainments under the experimental system for those pupils who - broadly speaking - are in the top half and bottom fifth of the attainment range. Further comparisons of this type seem desirable (with additional analysis as explained in the Appendix). Of course, even such declines may be a small price for greater social cohesion and other political objectives; these are not matters on which we need enter here. The decision as to whether this system is to be adopted in the remainder of the Canton is due to be taken by popular vote in 1997.

MATHEMATICS

Poor school attainments in mathematics, particularly in arithmetic, have long been recognised as a major obstacle for British school-leavers in taking up vocational training. This is probably the main

[12] In schools with many immigrant pupils, German is treated as if it were the foreign language for the purposes of grouping pupils into three sets.

reason why, in considerable contrast to Switzerland, school-leavers in Britain with average or below-average attainments are virtually barred from craft-level training (NVQ Level 3) in engineering occupations.

As indicated at the beginning of this paper, international mathematics tests (the IAEP tests) permitting a quantification of the gap between the two countries were carried out in 1991; some 75 mathematical questions were put to samples of 13-year-olds, which included 3600 pupils in Switzerland, 900 in England and Wales and 1600 in Scotland.[13] The overall score attained by the median Swiss pupil was attained only by the top quartile English pupil; this is probably the simplest summary indicator of the difference between the countries in relation to subsequent possibilities of vocational training. In other words, the *average* Swiss pupil reached what used to be called in England 'Grammar school standards' (Grammar schools catered for roughly the top quarter of the ability range). Similarly noteworthy is that the score attained by the Swiss pupil at the lowest quartile was attained only by the median pupil in England; and the score of the lowest-decile pupil in Switzerland was attained by pupils only at about the thirtieth percentile in England. On that last criterion, it may be said that there are three times as many low-attaining pupils in England as in Switzerland.[14] Little difference was recorded between the top decile pupils in the two countries; that may be because the IAEP tests did not adequately discriminate amongst attainments at that level (the top decile pupil scored 92 per cent in Switzerland and 88 per cent in England), but it is also consistent with our own classroom-observations that the gap widens

[13] AE Lapointe, NA Mead, TM Askew, *Learning Mathematics* (Educational Testing Service, Princeton NJ, 1992); hereafter IAEP Mathematics. The tests were carried out in a fixed period of time, usually one school-period of 45 minutes (curiously, 'the results of students who omitted questions at the ends of sections because they did not reach them were excluded from the calculations [of 'per cent correct'] for those questions'; *ibid.*, p.141). Calculators were not allowed. For brevity, we have used the words 'England', 'English', etc., to denote England and Wales. The results for Scotland were sufficiently close to those for England and Wales as not to warrant reporting them separately in the following account.

[14] These summary and approximate indications of the gap between the countries were derived by graphical interpolation from the percentile scores tabulated in the IAEP report, p.145, supplemented by unpublished information on medians (61.2 and 77.3, unadjusted for guessing) kindly provided by Dr Mead. The interpolated results quoted in the text above are after adjusting the original published scores for guessing (using the conventional formula) on the basis that 71 per cent of the questions were multiple-choice.

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amongst lower-attainers.

A more detailed analysis of the IAEP results by school-type carried out for Zürich confirmed in specific institutional terms the Swiss advantage in mathematics: *Realschule* pupils, that is, those who are in schools catering roughly for the *lowest third* of the academic attainment-range attained scores above those attained by the average pupil in *all* schools in Britain (a score of 57 compared with 51 per cent).[15]

The representativeness of the English sample was much less satisfactory than the Swiss sample in that only under half (only 47 per cent) of English pupils selected on a representative basis actually participated, compared with 80 per cent in Switzerland.[16] Schools with poor attainments are less likely to co-operate, partly because teachers in such schools are too busy coping with their heavier burden of problem-pupils, and partly because teachers are not particularly proud of the results of their efforts; it is thus no more than realistic to suspect that the true gap between the two countries' attainments is even larger than emerged directly from the published results of this survey.[17]

The following examples from the IAEP-tests illustrate the nature

[15] Urs Moser, *Was wissen 13-jährige? Schulische Leistungen und Schulstrukturen* (Amt für Bildungsforschung der Erziehungsdirektion des Kantons Bern, c. 1992), p.23. Analyses by main population areas show Zurich pupils as having similar attainments to those in French-speaking areas and in Ticino; but the Canton of Bern performed significantly less well (*ibid.*, p.16; nevertheless, even Bern was ahead of England).

[16] IAEP Mathematics, p.135.

[17] That low-attaining UK schools are less likely to participate emerged from a series of earlier studies (see eg D Foxman, *Learning Mathematics and Science: The Second International Assessment of Mathematics and Science in England*, National Foundation for Educational Research, Slough, 1992, p. 3 and n. 6). In an attempt to estimate the size of the response-bias in the IAEP survey, NFER kindly co-operated with our request to compute adjustment factors based on published GCSE attainments of schools that were approached for the IAEP survey and of those schools that participated. The originally published score for the lowest decile of 34.5 (unadjusted for guessing, IAEP Mathematics, p.145) was consequently lowered to 32. This method of allowing for bias in England can be regarded as only partial for the following reason. While most countries took a representative sample of pupils throughout the attainment range in each school, the procedure in England was based on sampling whole classes; classes in mathematics in English comprehensive schools are usually 'set' on the basis of ability, and it consequently seems likely that there were additional biases within schools as a result of lower response by low-attaining *classes*. The method of adjustment adopted here accounts, at a guess, for perhaps no more than half the total bias.

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and extent of English pupils' shortfalls in basic arithmetic. The average of seven temperature values (9, 7, 6, 0, 2, 8, and 10°C) was correctly identified by 67 per cent of Swiss pupils compared with only 37 per cent of British pupils.A subtraction problem 1003 - □ = 172 was solved by 72 per cent of Swiss pupils; the British proportion was 39 per cent. Calculations involving decimals present great difficulties to English pupils, and provided the most striking contrasts: 69 per cent of Swiss pupils were able to identify the correct decimal number equal to $^5/_8$, compared with 21 per cent of British pupils; 56 per cent of Swiss pupils, but only 13 per cent of British pupils, were able to name the smallest of four decimal numbers below unity (0.625, 0.25, 0.3753, 0.125); similarly, multiplying 9.2 by 2.5 was carried out correctly by 55 per cent of Swiss pupils, but by a mere 13 per cent of British pupils.[18]

It is sometimes said that performance in arithmetic by pupils in Britain may be lower than in other countries, but that British pupils 'compensate' for that weakness by better performance in other branches of mathematics, eg geometry or data handling. The IAEP survey indicates that it is more accurate to say, not that British pupils are better, but that their shortfall is not as great in other branches of mathematics as it is in arithmetic. Of all questions classified under 'arithmetic' in the IAEP tests, the percentage of correct answers by Swiss pupils was 67, compared with 49 by English pupils. The gap in questions classified under 'measurement' (eg the circumference of rectangles, or the volume of cubes) was slightly smaller: 53 per cent of Swiss pupils, and 40 per cent of British pupils, answered such questions correctly. In questions relating to 'algebra' 54 per cent of Swiss pupils answered correctly, compared with 43 per cent of British pupils. In 'geometry' the percentages correct were 71 per cent for Switzerland, and 63 per cent for Britain.

'Data analysis, probability and statistics' was the only branch in which the difference in attainment between the two countries could be described as negligible: 78 per cent of Swiss pupils answered correctly, compared with 75 per cent of British pupils. In contrast to Britain, very little explicit emphasis is placed on this branch of mathematics in Swiss schools. Probability and statistics are not taught at that age in Switzerland (note, however, the example on averages

[18] All except the last of these questions were multiple-choice with four possible answers; the 'percentages correct' quoted in this and the immediately following paragraphs have all been adjusted for guessing on the same basis (see fn. 14) that 71 per cent of all questions were multiple-choice (a more accurate calculation would take into account that the proportions varied according to topic).

mentioned above), nor is much weight given to 'tables and graphs'.[19] It needs to be asked whether the time invested in teaching these topics to British pupils at young ages would be better used by giving greater emphasis to basic arithmetic.

Our teams' observations of Swiss *Realschule* classrooms confirmed the picture recorded in the IAEP survey: English teachers and school inspectors were consistently surprised that these nominally low-attaining pupils in Switzerland were working at standards comparable to what would be expected of pupils in middle-level sets in good English schools. That judgement referred as much to the mastery of curriculum content as to the consistency, orderliness and clean presentation in pupils' exercise books. A greater concentration on arithmetic seems to characterise Swiss teaching; there is also greater emphasis on three-dimensional conceptualisation linked to technical drawing.

The following examples illustrate the standard of work by pupils that we observed in the final two years of Swiss secondary *Realschulen*, corresponding to Years 9 and 10 in English comprehensive schools in below-average sets. Calculation of the circumference and area of circles was taught to Swiss *Realschule* pupils at age 14 (corresponding to our Year 9), as also was the construction of a trapezium from given dimensions of certain sides and angles. Under the 1994 revision of the National Curriculum, areas of circles are expected to be taught only to *average*-ability pupils in England at age 15 (Level 6 of the National Curriculum); below-average pupils are expected to be two years behind (at Level 5).[20] Fifteen-year-old Swiss pupils (our Year 10) at *Realschulen* solved complex problems involving proportions of the kind that arise in 'mixtures'; for example: 'Chocolate type A costs 12 SwFr/kg, chocolate type B costs 21 SwFr/kg. A company wants to produce Easter bunnies, each weighing 250g and selling at SwFr8.20. The cost of the material is to be 50 per cent. Calculate how much of the two types of chocolate will be used'. In Britain problems of this type are expected to be set only to above-average 16 year-olds (NC Level 7 and above). Similarly, the application of Pythagoras is expected to be taught to *Realschule*

[19] Equally in Japan, probability and statistics are not part of the school curriculum at this age but are deferred till 17-18.

[20] Under the Dearing proposals of May 1994, areas of circles were recommended to be moved to Level 7, ie they were thought only suitable for *above-average* 16 year-olds; but in the draft Order issued at the end of 1994 this topic remained at Level 6 (to which it was moved in 1991; previously in the original 1989 Order, it was to be recognised at Level 8 of AT8).

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pupils at age 14-15 in Switzerland, but only to above-average pupils at age 16 in England (Level 7 of the National Curriculum). These examples, in summary, support the broad judgement reached by our team of inspectors and teachers that in basic mathematical processes Swiss *below-average* pupils were working at a standard that is ahead by a year or two of what is expected in England even of *average* pupils.

Teaching style

We now describe certain important aspects of teaching observed in Swiss classrooms which are typically different from our observations of English classrooms, and which seem to contribute to pupils' better attainments. Much of what has to be said on these matters applies also to other subjects; but it is well to illustrate the issues in terms of mathematics teaching in which there are particularly serious difficulties in England. That subject - as teachers often say - is more 'linear': what is learnt by a pupil today depends more strongly on what he has learnt yesterday (the learning of foreign languages is similar in this respect). The differences between the countries in this subject are perhaps for that reason particularly clear. We shall deal first with observed differences in teaching styles, and leave to the end of the paper a consideration of underlying differences in circumstances (mostly beyond the control of the teacher) that may encourage Swiss - but not English - teachers to adopt such methods.

On entering a classroom in Britain, pupils are typically to be found dispersed around tables in groups of four to six; inevitably some have their backs to the blackboard. They work 'at their own pace' - a fundamental ideal of Progressive educationists - through exercises from books, booklets, worksheets or cards; most pupils work individually - even though notionally they are supposed to be 'working in groups'. Pupils within a single classroom are usually at very different stages, according to their supposed individual levels of ability, and they work on different topics and from different books or other teaching material. This applies even in schools where pupils have been 'set' in parallel classes according to their level of attainment. Whole-class teaching is to be observed for only a small fraction of the lesson-time in British mathematics classrooms, particularly rarely in classes for average and below-average pupils. It often takes place for no longer than a few minutes at the beginning of a lesson when the teacher makes organisational announcements, or when a new topic is introduced. For most of the time pupils are left to their own resources. The teacher's role is mainly to help indi-

vidual pupils when there are difficulties and to check their work. Pupils are addressed by the teacher usually only if they request it. Often several pupils need the teacher's help at the same time; they therefore put their hands up - or queue at his desk - waiting until the teacher is free to help them. Some teachers have a rule for length of queues, such as 'not more than four waiting at my desk at a time'; other teachers walk around the class with a 'crocodile' of pupils trailing behind them waiting for their questions to be answered. The pressure on teachers means that checking of pupils' work is often cursory; many pupils do not receive adequate support from the teacher to carry out their work successfully, and poor understanding by pupils frequently goes unnoticed. Average pupils, and even more so those who are below-average, consequently suffer. As HMI recently observed in relation to mathematics classes, the use of individualised teaching programmes 'places undue responsibility on pupils for controlling the pace and quality of their learning'; the proportions of pupils who 'were successful in their work' is as low as 50-60 per cent, and this 'did not help motivation'.[21] As many others have said, for many pupils working 'at their own pace' means 'doing as little as you can get away with'; pupils may often behave as if they were engaged on their work, but their learning-time is not used efficiently.

There is of course some variation to this picture. At one extreme, virtually no whole-class teaching takes place; and pupils spend much of their lesson-time on 'holding activities' which can hardly be recognised as contributing systematically to their progress, eg joining dots on a grid to make patterns, cutting out triangles and calculating ratios of their sides (a time-absorbing task observed in classes for 16 year-olds).[22] In high-ability sets, whole-class teaching is to be observed more frequently and greater attempts are made to ensure that all pupils in the class work at the same level.[23]

[21] Ofsted, *Science and Mathematics in Schools: A Review* (HMSI), 1994), p. 16; and *Mathematics: Key stages 1,2,3 and 4* (HMSO, 1993), paras 19-20.

[22] The term 'holding activities' (ie activities to keep some pupils busy while the teacher deals with others) is used in the Ofsted report (*op. cit.*, 1994) p.21.

[23] Alternative teaching styles in English mathematics classrooms were described in the Cockcroft report, *Mathematics Counts* (HMSO, 1982), esp. pp.91-4 and 150-2. The report commends more 'exposition' and 'discussion', and the difficulties of teaching a class divided into groups are recognised: but the discussion is not incisive. The general and fundamental contrast between British and Continental classroom practice was not explained, probably for lack of experience by those who compiled the report (there is one reference to teaching practices in a Danish classroom, but not to other countries, see pp.103 and 236). See also the critical discussion of 'Cockcroft styles' by J Backhouse, L Haggarty, S Pirie, J Stratton, *Improving the Learning of Mathematics* (Cassell, 1992), p.129.

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The Swiss secondary school classroom is typically different. Desks are often arranged in a 'horseshoe' or similar pattern, with the teacher's desk in the centre of the open end or to the window-side of it, and sometimes with one or two pupils' desks in the middle of the open end to permit pupils with habitual difficulties to be nearer to the teacher. There is usually an overhead projector in addition to a blackboard; the main advantage of the OHP, from the teacher's point of view, is that it allows more continuous supervision and eye-contact with pupils, since the teacher faces the class while writing. A large part of each lesson - between half and two thirds - is devoted to continuous interaction between the teacher and the whole class. This form of instruction is not a lecture, interspersed with occasional questions by the teacher to pupils - as 'whole-class teaching' is often understood in England; rather, the teacher starts with a realistic problem, and develops solutions and concepts through a series of graded questions addressed to the whole class. Questions may be put every minute or two; the teacher may wait half a minute before calling on a pupil - whether he has raised his hand or not - to answer or write the next step on the blackboard (or overhead projector). Pupils are thus guided towards discovering solutions themselves (*fragend entwickeln*).

Virtually the whole class is mentally engaged in the learning-process during this oral part of the lesson. From the breadth of response in the class, the teacher is able to judge how far he needs go in the exposition of difficult steps; and he sees which pupils are likely to require individual help during the subsequent period devoted to written exercises. Only after the oral stage has been adequately mastered is the class asked to carry out written exercises on their own (sometimes continued as homework). Virtually all pupils in the classes we observed completed their work successfully. Grouping of pupils within a class, to permit some form of joint working, was sometimes seen in Swiss classes; but the important contrast with England is that it occupied a limited fraction of the lesson-time.

To English teachers familiar with the long tail of under-achieving pupils in their mathematics classes who have trouble in understanding what they are expected to do, the degree of evenness amongst Swiss *Realschule* pupils in their attainments comes as a considerable revelation as to what lies within the realm of possibility.[24] In Swiss

[24] The slightly higher proportion of Swiss pupils with separate SEN provision has been noted above (fn. 6); it warrants detailed further investigation as to how much this may contribute to the greater evenness of attainments and to the greater feasibility of whole-class teaching in Swiss schools.

classes catering for the next higher range of abilities - in *Sekundarschulen* - the same style of teaching is employed, though the approach is more abstract and conceptual. The pace of teaching is faster, partly because of pupils' higher ability, and their range of attainments is remarkably even. In English mathematics classes which have been 'set' by attainment, it might be thought that the middle sets would show a comparably narrow range; but it seems that Swiss teaching methods lead to a distinctly greater evenness even amongst middle-ability groups.

Let us next look at other differences in teaching: textbooks, calculators, investigatory methods, class-size and teaching time.

Textbooks

Textbooks are fundamental to the teaching process in Swiss mathematics classes, even if they are not always visible during the intensive oral phase of the teaching-process that occupies most of the lesson-time. The textbooks are somewhat different in construction, and used differently, from those familiar in England. English pupils' textbooks are mostly in the nature of self-instruction ('teach yourself') manuals. Swiss pupils' textbooks - usually a single book for each year of schooling - contain little self-instruction material but plenty of exercises; and they are thinner (comparing the textbooks required by a pupil for the whole year). There is a textbook for each level of schooling (similar to the yellow, red, blue and green versions of some English textbook series for pupils of different levels).[25] Most important, a thick teacher's manual accompanies each textbook; it provides detailed suggestions for teaching each page (sometimes, pair of pages) in the pupils' book, including the precise teaching aims, master copies for OHP transparencies, and a suggested year-plan indicating which pages to cover each week of the year. Teachers' manuals are also available for many English textbook series, but their nature and use is different - probably because the authors realise that there is less whole-class teaching; teachers' manuals in England may be a 'good source of ideas', as HMI recently put it, but 'few teachers referred to these manuals'.[26]

[25] The English parallel series for different levels of attainment are written in styles descending markedly from the hieratic to the demotic; see also P Dowling, A touch of class: ability, social class and intertext in SMP 11-16 (in D Pimm and E Love, eds, *Teaching and Learning School Mathematics*, Hodder and Stoughton, 1991, p.137). The Swiss parallel series, with less intention to act as teach-yourself manuals, display a more even dourness.

[26] Ofsted, *The Teaching and Learning of Number in Primary Schools* (HMSO, 1993), para. 46.

Swiss textbooks are drafted by groups of experienced teachers to cover the prescribed curriculum of the Canton; they are trialled, revised in the light of experience, and then approved by the Cantonal education authorities. The prescribed curriculum is a brief schematic document which specifies the topics to be covered by the different schooling levels in each year.[27] The authorised textbooks are in the nature of an approved amplification of the legally-binding curriculum; they have much the same role as the *Scheme of Work* in English schools (except that in England each school is expected to develop its own *Scheme* in an attempt to meet the requirements of the National Curriculum: a difficult and laborious task). The use of the authorised textbooks is optional in Swiss schools; teachers may choose alternative or supplementary material, and they may place less emphasis on some topics than on others. Since Cantonal textbooks are on the whole close to the needs of most pupils and teachers, they are however extensively used. Variations in attainment between parallel classes in the same school, and amongst schools of the same level, are noticeably smaller in Switzerland than in Britain; the predominant use of the same textbook is undoubtedly an important factor.

In English schools teachers frequently reject the idea of teaching according to a single textbook. They often say that they have not found a single textbook that is adequate in coverage of topics, or in providing sufficient exercises for consolidation. But doctrinal opposition to anything smacking of rote-learning is probably at the root. It is as if the use of a main textbook might be taken as evidence that they are failing in their duty of providing a mix of instructional material professionally tailored to the actual mix of pupils' attainments in their class. Some schools use their very own scheme of instruction, transmitted on duplicated sheets from one generation of teachers to the next (much 're-inventing of the wheel' from first principles is thus to be observed). More frequently, a variety of printed textbooks and workbooks is available in the classroom; but often there are insufficient copies of a single text to be used simultaneously by the whole class (lack of resources is another reason often advanced for not teaching from books). Pupils within a class are therefore commonly to be observed sharing textbooks.

British pupils do not usually take textbooks home: they are avail-

[27] The latest version of the Zürich curriculum also indicates the depth at which topics are to be taught: (1) introductory, (2) working procedures, (3) mastery (*aufgreifen, durcharbeiten, festigen; Lehrplan für die Volksschule des Kantons Zürich*, 1991, p.259).

able only for use in the class, and are not intended to be used for routine revision outside school-hours. Swiss pupils, in contrast, each have their own textbook, and are expected to take them home for their homework. They and their parents know what material is to be covered, and pupils use their books for revision as necessary.

Calculators

English schooling prides itself on its readiness to introduce new technology into its classrooms; the requirement to use calculators even in *primary* schools is now embodied in the legally binding provisions of the National Curriculum for England. In secondary schools, as the IAEP survey reported, by the age of 13 some 90 per cent of English pupils both owned and used a calculator at school; in Switzerland, a similar proportion at that age owned calculators, but only 50 per cent of Swiss pupils of that age *ever* used calculators in school.[28] At younger ages, the long-established view that the mind of the pupil needs thorough training in mental arithmetic has so far remained paramount in Switzerland (as in many other countries, including Japan), and has not been displaced by the advent of the pocket calculator. The problem with electronic calculators is that they *conceal* the process of calculation from the user, and are thus quite different in their educational value from an abacus.

Calculators were in use in almost all mathematics lessons that we observed in English secondary schools. It was not unusual to find several pupils making fairly obvious calculator errors, which went unnoticed by them because of poor capabilities in making advance mental estimates of results. In Switzerland calculators were observed only very exceptionally in primary schools; even in secondary schools they were not visible in most of the classrooms visited. When they were used we did not observe the kind of calculator errors observed in English secondary school classes; by that stage Swiss pupils are sufficiently adept in the mental arithmetic needed to assess whether a result obtained by using a calculator is likely to be correct.

Calculators in Swiss classes are used in *Realschulen* and *Sekundarschulen* mainly to enable pupils to obtain a precise result *more quickly* than they could with pencil and paper (for example, division by a multi-digit divisor - a calculation which is beyond most English pupils, even to a first approximation, without a calculator). For top-ability pupils in a *Gymnasium* class we observed 15 year-olds using programmable calculators (rather than computers) while

[28] IAEP Mathematics, p.57.

being introduced to branching processes and loops in a problem in the theory of games; work at this level was not seen in English schools by pupils at that age.

Computers were not observed as part of systematic mathematics instruction in either country. In England there was frequently a computer in a corner of the room, used by one or two pupils while the rest of the class worked on their various exercises; the most active use observed of computers in English schools was in other subjects, where they were used as word-processors. In Swiss *Realschulen*, computers were used in technical drawing classes for 15 year-olds (CAD MacDraw programmes).

Investigations

A time-consuming constituent of English school mathematics - conspicuously absent in Switzerland - is laid down in the National Curriculum as Attainment Target 1: it is entitled 'Using and Applying Mathematics' and purports to require pupils to apply their 'mathematical knowledge to practical and real-life situations'. In reality it consists of extended tasks, often open-ended for which there is no single correct answer; its importance is supposed to lie in the *process* rather than the *product* (as educationists put it). A simple example recommended for a mixed ability class is:-

> Start with any two numbers less than 10 (say 1 and 5). Make a series like this: 1, 5, 6, 1, 7, 8, 5, ... How is this series obtained? What are the next six numbers? Choose other starting numbers, and investigate how many series you can make. What happens if you use numbers in other bases?[9]

High-ability 13 year-olds were given the following task:-

> The number 33 can be expressed as the sum of two primes: 33 = 31 + 2. However, 35 cannot be expressed as the sum of *two* primes, although it can be expressed as the sum of three primes: 35 = 5 + 13 + 17. Investigate the number of primes needed for different numbers.[10]

A 'mathematical' investigation set to 14 year-olds had only a nominal mathematical content:-

> Design and carry out a survey which has something to do with Easter Eggs.

And 16 year-olds were asked:-

> Find the relationship between the *number* of dots inside geometric shapes drawn by connecting dots arranged in grid form, and the *area* of those shapes.

The main work to be carried out by pupils in such investigations consists of wordy written accounts of what they plan to do, what

[9] From Schools Council, *Mixed-ability Teaching in Mathematics* (Evans/Methuen, 1977), p.36.

[10] This is Vinogradoff's problem of 1937, as yet only-partially solved.

they did, difficulties they encountered (pupils know that to obtain a good mark it is important to describe many false starts and false trails), limitations of their work, etc.

Exercises of this sort in an English class may serve as convenient 'time fillers' or 'holding activities', keeping pupils busy while teachers - using their individualistic teaching methods - try to meet the needs of an over-wide diversity of pupils' attainments. No such exercises were observed in Swiss classrooms. This is not to say that Swiss pupils do not carry out exercises which 'use and apply mathematics' (to use the terminology of the English National Curriculum); on the contrary - the Swiss approach is to ensure that problems are realistic, but also that they are soluble so that a sufficient number of problems can be tackled within the available time to ensure mastery (and even 'over-learning') by virtually all pupils in the class.[31] For example (a problem for middle-attaining 13 year-olds):-

> In 1989 the town of Zurich disposed of 144,695 tons of household refuse. How much was produced by each of the 361,000 inhabitants? How many refuse sacks taking 2.5kg on average were filled by a family of four in a year? Suppose the refuse was loaded on a train, in which each wagon takes about 20 tons and is 10m long. How long would a train be that could take the refuse of Zurich for the year 1989?[32]

There is of course much to be said in favour of extended projects, in that they enable pupils to exercise their creativity and independence; it applies as much to other subjects (science or technology) as to mathematics. The difficulty in the context of current English teaching practice is that they have been inadequately limited in time, at the cost of more systematic learning practices.

[31] The same approach is adopted in the Netherlands where 'realistic' mathematics (ie starting from contextual problems) has become an important pedagogical movement (K Gravemeijer, M van der Heuvel, L Streefland, *Contexts, Free Productions, Tests and Geometry in Realistic Mathematics Education*, State University of Utrecht, 1990).

[32] From *AVO Math 7 m* (Zurich, prov. ed., 1992), p.38. The proposed 1994 revision of the English mathematical curriculum, as published for consultation, included a suggestion for integrating the application of mathematics with each of its substantive topics (arithmetic, algebra, geometry). This was opposed by the Royal Society together with academics of the Joint Mathematical Council in a curious way: they 'welcomed the principles of integration' but, in the spirit of Augustine, thought 'the time is not yet appropriate' (RS press release, 9 May 1994). The suggestion was not adopted.

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Class-sizes and teaching time

The main cost of schooling is the number of teachers in relation to the number of pupils. As mentioned, mathematics classes in Switzerland at age 13 were recorded in the IAEP survey as averaging 18 pupils compared with 22 in England. Our visits to Swiss secondary schools showed some variation in class-sizes (up to 25 pupils are permitted per class in Zürich) without any obvious relation to pupils' attainments; the greater evenness of Swiss pupils' attainments seemed the more important factor in making teaching easier for the teacher, and in making learning easier for pupils. Total instruction time for pupils each year was much the same in the two countries, but time devoted to mathematics lessons was about a quarter higher in Switzerland than England (250 compared with 190 minutes a week; that is, 16 per cent compared with 12.5 per cent of instruction time); lessons in mathematics were given every day of the school-week in England to only 17 per cent of pupils, while in Switzerland 60 per cent of pupils had a mathematics lesson every day.[33] Higher attainments in mathematics in England may thus require, not greater resources in total, but a shift in the balance of the curriculum towards mathematics, together with greater emphasis on teaching that subject each day to provide consistent reinforcement.[34]

SCIENCE

In English schools great emphasis is placed on science teaching, not least because of the comparatively low proportion of young people qualifying in engineering and technological occupations (about two and a half times as many qualify in engineering occupations at craft level in Switzerland as in England). In an attempt to raise science attainments in England, science has been made an obligatory subject

[33] IAEP Mathematics, p.49. The use of 'double-periods' in some schools in England (eg twice 35 minutes to form a continuous lesson of 70 minutes in mathematics) lowers the efficiency of learning, since pupils' concentration falls towards the end of such an extended period in mathematics (whereas in practical work a longer period is an advantage).

[34] Two within-country correlations calculated by IAEP deserve mention: correlations within most countries between pupils' attainments and *frequency of teacher-presentation* were positive; on the other hand, correlations between attainment and *frequency of group-work* were negative (p.53). That is to say, pupils did better in those classes in which teachers spent more time in active teaching, and they did better in those classes in which less time was devoted to learning in groups. Unfortunately, IAEP did not carry out multiple regression analyses, nor publish the size of regression coefficients.

under the National Curriculum for all pupils, starting as early as the age of 5. However, insufficient mathematical skills often make it difficult to teach science - particularly physics - in any valuable depth to English average and below-average pupils even at secondary-school ages. In this section we explain the major differences in science teaching in the two countries on the basis of our own classroom observations, amplifying the IAEP test results in that subject.

Time spent and pupils' attainments

The Swiss devote a quarter *less* time in secondary schools to science subjects at age 13 than in England, amounting to 10 per cent of instruction time compared with 13 per cent in England (152 compared with 194 minutes a week). Taking mathematics and science together, much the same *total* time is devoted to these subjects in both countries (380-400 minutes, or a quarter of total instruction time), but within that total there is a notably greater emphasis in Switzerland on mathematics than on science.[35] Time devoted to science in England in the final two years of schooling usually increases, depending on the choice of optional subjects; most pupils (some 85 per cent) took 'double award' science in 1993-94 which requires some 20 per cent of school time.[36] The time devoted by Swiss pupils in *Real-* and *Sekundarschulen* to science throughout the three years of their secondary schooling is closer to 'single-award' science in England which is expected to absorb 10-12 per cent of school time.

Despite the substantially lower time devoted by Swiss pupils to science, the IAEP tests in that subject - carried out in parallel to the mathematics tests mentioned above - showed Swiss pupils attaining substantially higher scores than English pupils. The total of 64 IAEP questions covered the broad range of science topics: life sciences, physical sciences, earth and space sciences, nature of science. The score attained by the median Swiss pupil was attained by English pupils only at the top thirtieth percentile of the attainment range (whereas in mathematics it was the top twenty-fifth percentile); and the Swiss pupil at the lowest decile attained a score that in England was attained only at the lowest thirtieth percentile. On that last criterion, it may be said - very much as in mathematics - that there were three times as many very low attaining pupils in England as in

[35] AE Lapointe, JM Askew, NA Mead, *Learning Science* (Educational Testing Service, Princeton NJ, 1992), p.49 (*IAEP Science* hereafter).

[36] DfE, *Statistical Bulletin 5/94*, para. 12; Ofsted, *Science: Key Stages 1, 2, 3 and 4: Fourth Year, 1992-93* (HMSO, 1993), p.17.

Switzerland.[37] An analysis of the IAEP survey by school-types for Zürich confirmed that *Realschule* pupils (as explained, roughly the lowest third by academic attainment) did as well as average pupils in England and Wales.[38]

Demonstrations and own experiments

In considering how to improve pupils' attainments in science, 'it may not be the number of minutes of science instruction that is important, but how that time is used', as the IAEP report on science put it.[39] A stark contrast between England and Switzerland was recorded by the IAEP in the extent to which experiments are conducted by pupils and the extent to which they are demonstrated by the teacher: 83 per cent of English pupils carried out experiments on their own at least once a week, compared with only 24 per cent of Swiss pupils. England had a higher proportion of pupils performing their own experiments than any other country participating in that survey.[40] Within each country, the correlations between pupils' scores in science and the amount of pupil-conducted experiments were on the whole significantly negative; that is to say, within each country pupils obtained higher scores in those schools which required *less* experimentation by pupils on their own.[41]

The great priority attached in English science classes to *pupils' carrying out own experiments*, rather than seeing them *demonstrated* by the teacher as part of the teaching process, is in accord with English educationists' doctrines that pupils need to 'discover' the truth for themselves. That priority was embodied, and much extended, in

[37] Interpolated graphically from the percentile scores in *IAEP Science*., p.143,and unpublished information on medians (78.1 and 70.3,unadjusted for guessing). The gap between the countries in science is very slightly narrower than that for mathematics. The poor participation rate by English schools (only 48 per cent of sampled pupils, *ibid*, p.133) makes it likely that the true gap between English and Swiss pupils is greater than shown in the IAEP survey (see fn. 17 above).

[38] Moser, *op. cit.*, p.24. There were no significant differences in science between the average attainments in the various language-areas distinguished in the IAEP analysis (*ibid*., p.17).

[39] *IAEP Science*, p.49.

[40] *Ibid*., pp.51 and 147.

[41] *IAEP Science*, pp.50-51. The correlations calculated within each of the participating countries were significantly negative in eleven countries, significantly positive in only one country, and not significantly different from zero in eight countries (including England!). It is a pity that detailed results were not reported for the 'not significant' relations, since they might have been combined to yield a joint result which reached statistical significance.

the English National Curriculum for science under Attainment Target no. 1, 'Scientific Investigation' (called 'Experimental and Investigation Science' under the revised proposals of 1994, with minor changes in substantive emphasis). This approach has been subject to even sharper criticism than the corresponding investigatory Target in mathematics: in science, pupils are required to develop their *own individual* investigations; such investigations are very time-absorbing, and time is too often used in an unsystematic way from the point of view of inculcating established scientific facts, relations and theories.[42]

On our visits to English science classes we observed that, even when more or less the same science experiments were carried out by a whole class or group of pupils, the time was often not well used. Examples included groups of pupils 'building an electric motor' from primitive materials - a cotton reel wound with a piece of wire, paperclips used as pivots and a plastic beaker used as a stand (much time was spent by pupils in trying to balance the 'coil' on the beaker so that it would turn under current). Lengthy measuring experiments, with an emphasis on alternative (but essentially trivial) methods for 'presentation of data', are also typical of English science classes. For example, in a biology lesson concerned with the relative influence of inheritance and environment on human characteristics, most of the lesson-time (a 'double lesson' of 70 minutes) was devoted to pupils collecting data on each others' hand-sizes, thumb-lengths, colour of hair and eyes, and whether or not they could roll their tongue (an inherited characteristic of no known significance - as, indeed, the teacher explained). Pupils were asked to 'think about how to record, analyse and present this information', and additional time was to be spent the following lesson on pie charts, bar charts, etc. Currently accepted doctrine in English schooling is that pupils benefit from a 'sense of ownership' of their *own* data; but, as educationists from the University of Leeds noted following extensive observations of

[42] As HMI recently observed, 'in a significant proportion of lessons ... insufficient attention [is] given to explaining, reinforcing and consolidating key concepts; see Ofsted, *Science Key Stages 1, 2, 3 and 4* (HMSO, 1993), para. 18.

[41] See JF Donnelly, AS Buchan, EW Jenkins, AG Welford, *Investigations in Science Education Policy: Sc1 in the National Curriculum for England and Wales*(Centre for Policy Studies in Education, U Leeds, 1993), esp. pp.3,6,8. Note their remarkably incisive comments on the difficulties created for teachers in having to supervise a diversity of individually-planned activities.

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English science lessons, 'the alleged benefits of ownership of [pupils'] work are occasionally present, more often not'.[43]

On our visits it seemed evident that many pupils had gained only a superficial idea of the principles underlying their individual experiments, and some had developed a wrong understanding. Teachers tended to refrain from instructing pupils in the scientific principles at issue; rather, in accordance with views long commended by HMI, they wished to encourage pupils to 'think scientifically for themselves', 'speculate about scientific ideas,' and 'pursue their own lines of enquiry'.[44] There may be something to be said in favour of the HMI-approach, but it seems to have been taken too far in English schools. In the words of the Leeds educationists: 'very frequently pupils end an investigation confused or mistaken about the science on which they have been working'; the present state of English science teaching, they thought, 'undermines ... the fostering of scientific knowledge'.[45]

Pupils' own experiments in Switzerland are more closely guided by the teacher; as remarked by Swiss teachers, this is especially important for below-average pupils since they are more easily discouraged if their experiments fail or run into difficulties. Experiments carried out by Swiss pupils are often preceded by a demonstration to the whole class performed by the teacher; subsequently, the teacher involves pupils in the learning process by discussing the implications with the class as a whole on the blackboard or OHP. In other science lessons the Swiss teacher may integrate demonstration with interactive discussion and questioning: pupils are asked to anticipate possible results, explain their reasons for anticipated and actual results, and consider the next experimental step necessary in order to verify those reasons. In these ways Swiss pupils participate more efficiently in the process of 'discovering' scientific relationships. Dictating notes to pupils in a lecturing style, as sometimes observed even in low-attaining science sets in England, was not observed in

[44] Ofsted, *op. cit.*, paras. 15, 24.

[45] Donnelly *et al.* (*loc. cit.*) gave the following example: 'We have seen pupils convinced that the "froth" visible in a boiling yeast suspension meant that the enzymes present functioned more effectively at 100°C than at room temperature [when, in truth, the enzymes have been destroyed at that high temperature]. Meanwhile a harassed teacher was either unaware of the situation, or uncertain about the ... legitimacy (sic) in [the currently approved] teaching context, of correcting this impression'.

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Switzerland.[46]

Balance of science topics

Styles of teaching, expressed most clearly in terms of the greater role of demonstrated experiments in Switzerland and the smaller role of pupils' own experiments, formed the main difference observed between the two countries' science lessons; that difference, in turn, affected the utilisation of lesson-time and the pace of pupils' learning. Differences in the scope, balance or order of topics were not noticeable, with one exception. It related to the *order* in which topics are taught: in Switzerland physics courses are delayed till 14-16, when pupils' mathematical skills are expected to be sufficiently developed to permit teaching in some technical depth; in preceding years at Swiss schools pupils correspondingly spend more time on biology and chemistry.[47] In England, all topics are taught throughout.

The IAEP survey analysed pupils' knowledge of science according to four main topics (life sciences, physical sciences, earth and space sciences, nature of science - ie the experimental method) and three types of 'cognitive process' ('knows, uses, integrates'); under each head, average Swiss scores were ahead of English scores. In questions on physical sciences the gap was a little smaller, perhaps because of the delayed age in teaching physics in Switzerland. The gap was also a little smaller in questions on the 'nature of science', where the greater time spent on pupils' experimentation in English schools might be suspected of conferring an advantage; but, as indicated, Swiss average scores in both these aspects remains ahead of

[46] This inappropriate variant of whole-class teaching may be peculiar to England; it was the only country in the IAEP survey (pp.50-51) for which a *negative* correlation was reported between pupils' scores and the 'amount of listening to science lessons'. Significant positive correlations were reported for eight other countries. The different character and role of science textbooks and teacher's guides in the two countries deserves fuller treatment than possible in the present context. Such a comparison could profitably begin with the Swiss chemistry textbook and accompanying teacher's guide by H J Streiff, K Bolleter, *Chemie* (LKZ, 1992, pp.262, 200); these were recognised by English teachers who examined them as providing significantly better aids for teachers and pupils than material currently available here, and as well worthy of translating into English.

[47] In more detail: for pupils in *Realschulen* and *Sekundarschulen*, physics is taken only in their final year, that is, at age 14-15; in *Gymnasien* the delay is till 15-16, though an introductory basic course (*Propädeutikum*) may be provided at 14.

English scores. In questions on 'using science', where it might also be thought that the English approach would confer an advantage, the Swiss were distinctly ahead.

PRACTICAL SUBJECTS

The difference between what is frequently termed the English 'academic bias' in schooling and the Swiss preparation-for-life-and-work emphasis (traceable to a continuing Pestalozzian influence) is manifest most clearly in the teaching at secondary schools of practical subjects such as woodwork, home economics or technical drawing. The greater need to take advantage of technological progress, and to provide higher levels of education particularly for pupils who previously went into low-skilled work, have led both countries - in, say, the past twenty years - to revise teaching in this broad area of the curriculum; but, despite the similarity of the technological pressures in the two countries, the gap between them in what is provided at schools in these subjects has grown significantly in this period.[48]

Until some twenty years ago the teaching of practical subjects in Britain and in Switzerland was recognisably similar: courses were offered in a variety of fields, such as woodwork, metalwork, home economics, textiles. Pupils were taught practical skills in these subjects-areas, and the objectives aimed at in British secondary schools were broadly comparable with those in Swiss schools: the emphasis was on achieving *high* standards in a limited range of materials (eg metal or food, but rarely both). Courses on practical subjects were directed in both countries more particularly to pupils leaving school soon after the end of compulsory schooling.

In the past generation it has increasingly been thought desirable in Britain that practical subjects in some form should be taken by *all* pupils till the end of compulsory schooling. This raised the question, as it was put in 1967, whether practical subjects as traditionally taught could provide 'a sufficient intellectual challenge for the gifted

[48] The account given in this section draws on our previous comparisons of the teaching of practical subjects which included two further countries (Britain's industrial skills and the school-teaching of practical subjects: comparisons with Germany, the Netherlands and Switzerland, *National Institute Economic Review*, May 1993; and *Compare*, 1993, no.3). The present version provides additional details on Switzerland and on recent developments in Britain.

pupil'.[49] Changes were progressively made to the way practical subjects were taught in Britain to suit what educationists thought were the needs of 'gifted' pupils. The changes culminated in the introduction of the National Curriculum for 'Technology' in 1990; this was a newly-contrived and very broad subject, combining elements of Craft, Design and Technology (itself a combination, hardly ten years old, of earlier single-material subjects), home economics, art and design, and business education. The new provisions led to highly unsatisfactory classroom outcomes, as attested in reports from several sources issued as from October 1991.[50] Public concern became sufficiently pressing by June 1992 for the Secretary of State to call for a revision of the Order. Proposals for a new Order were published in December 1992 and revised in May 1994 (by the School Curriculum and Assessment Authority under Sir Ron Dearing); a draft of a new Order was issued at the end of 1994.[51]

In Switzerland the teaching of practical subjects had also been extended in recent years to an increasing proportion of pupils. Until 1992 these subjects were taught in Zurich obligatorily in *Realschulen* (ie schools for below-average pupils) for three years at ages 13-15, and were available as optional subjects in *Sekundarschulen* for the final year at age 15; since 1992 they have been made compulsory for all pupils apart from those in *Gymnasien*. However, in contrast to Britain, the extension of the teaching of practical subjects to a broader ability-range was not accompanied by fundamental changes in the objectives of these subjects nor in the way they were taught.

On visiting a woodwork or metalwork class in Switzerland, pupils were usually found to be each working on an object to the same specification. The emphasis was on *making* real artefacts (not models) suitable for the capabilities of pupils in that class, and on finishing them to a high standard. Skills were taught systematically: they

[49] Schools Council, *A School Approach to Technology* (drafted by DIR Porter, HM Inspector of Schools), Curriculum Bulletin no. 2, London, HMSO, 1967, p.13.

[50] A Smithers and P Robinson, *Technology in the National Curriculum: Getting it Right* (Engineering Council, May 1992); HMI, *Technology: Key Stages 1, 2 and 3* (June 1992); National Curriculum Council, *The Case for Revising the Order* (July 1992). These were preceded by an initial report related to the present study from the National Institute team, SJ Prais and E Beadle, *Pre-vocational Schooling in Europe Today* (October 1991). For a selection of academic responses, see chs. 3 and 4 in the volume edited by J Benyon and H Mackay, *Technological Literacy and the Curriculum* (Falmer, 1992).

[51] *Technology for Ages 5 to 16 (1992)* (DfE, December 1992); *Design and Technology: Draft Proposals* (SCAA, May 1994).

were demonstrated by the teacher to the class as a whole; pupils then applied and practiced them by working on their projects based on specifications or drawings provided by the teacher. The teacher checked pupils' progress at intervals to ensure that new skills had been absorbed properly, and he corrected malpractices.

Lessons in other practical subjects followed similar principles. For example, in home economics pupils prepared meals following recipes provided by the teacher; they also learnt about the dietetic and culinary properties of food. Having cooked the meal, they served and ate it - with due regard to table conventions. In textile classes Swiss pupils acquired practical skills in sewing, knitting and embroidery. At 13-14 they learnt to take measurements, make paper-patterns, and produce simple items of clothing for themselves (eg a zipped blouson); at 15 they worked from more complex commercially-produced paper-patterns. Swiss domestic sewing machines, with complex electronically-controlled optional facilities, were used routinely.

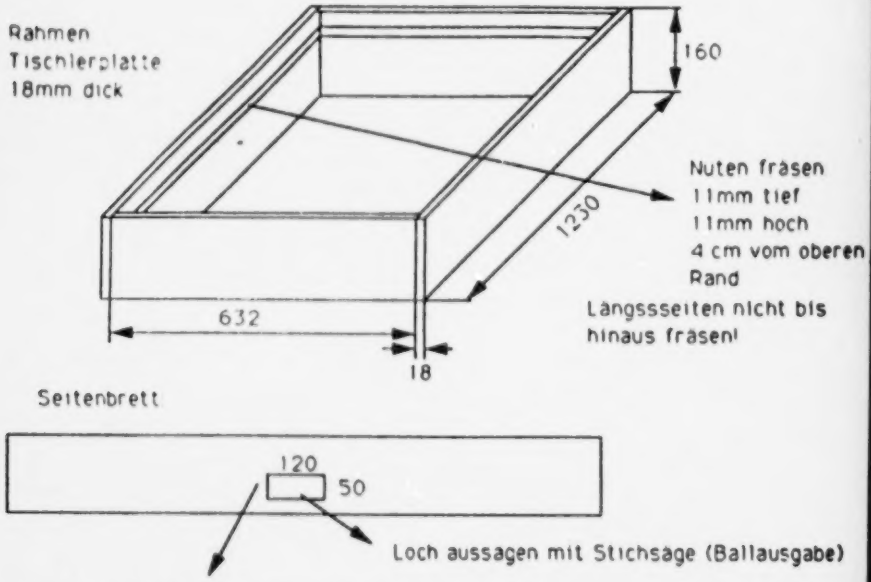
In Britain, following the principles of the 1990 National Curriculum, pupils in their Technology classes were given a broad theme, such as 'marina' or 'celebration'; within such a theme they were required to produce their individual projects. The first-step way to 'identify and state clearly needs and opportunities for design and technological activities through investigation'.[52] Pupils often spent many weeks - which might otherwise have been used for systematic teaching - in trying to decide on their projects; as HMI subsequently reported, 'pupils often spent too much unproductive time trying to identify needs; the outcomes were rarely satisfactory, and pupils sometimes become despondent about their lack of progress'.[53] For example, they observed that 'pupils in one school spent three weeks trying to identify a need associated with the theme of *communication*, but several became disillusioned and on week four brought in their own ingredients and made a pizza - a task which was quite unrelated to their earlier work'.[54] On our visits we observed 13-14 year-olds who, after weeks of brain-storming and research, ended in 'designing' and making some rather unoriginal wooden model boats and Christmas cakes, as embodiments - respectively - of the two themes mentioned

[52] *Technology in the National Curriculum* (hereafter: NC Technology), HMSO, 1990. 'Identifying needs and opportunities' was specified at Attainment Target no.1 in that document; the other three were 'generating a design,' 'planning and making', and 'evaluating'.

[53] HMI Report, para.16.

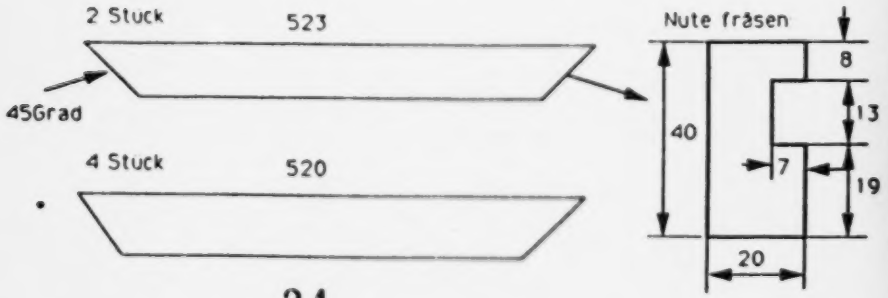
[54] *Ibid.* (our italics).

Figure 1. Example of woodwork carried out by 14 year-old Swiss pupils



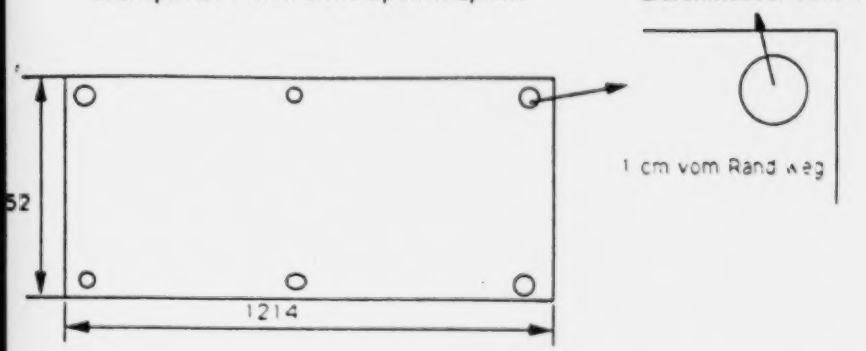
Bewahrt hat sich ein Schiebetürchen beim Loch, damit die Kugeln nicht hinausfallen beim Spiel.

Banden: Tannenholzleiste 20x40mm



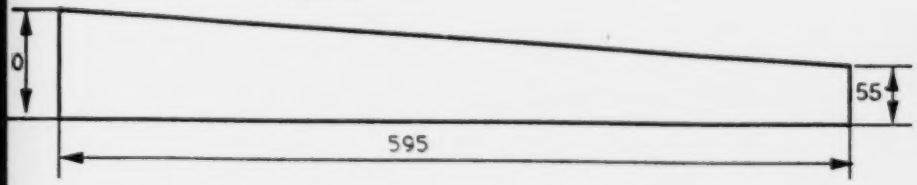
Grundplatte: 10mm dicke Sperrholzplatte

Durchmesser 60mm



Kugelbahn: Sperrholz 10mm

4 Stück



above, 'marina' and 'celebration'.

Once a 'need' had been identified and 'stated clearly', pupils were required to 'generate a design specification, ... produce a design proposal and develop it into a ... design'. Having worked on their artefact, they were required to 'develop ... an evaluation of the processes, products and effects of their design and technological activities'.[55] All this was required to be extensively documented in 'design folders'; the actual making of objects became marginalised, almost to the point of becoming extinct. As HMI noted, 'in many schools insufficient time was allocated to manufacturing activities. For many pupils practical work was limited to activities involving light card and paper for model-making'.[56] The emphasis on written paperwork - that is, on documented 'investigation', 'design', 'evaluation', etc. - also limited the complexity of pupils' practical projects to what each pupil was able to devise by himself. Academically-weaker pupils, if provided with specifications or drawings, might have learnt to produce complex products to high standards of quality; they were particularly disadvantaged by the requirement to engage in their own design work.

The individualised approach to teaching in English schools encourages each pupil to make something different; moreover, pupils are to 'work at their own pace', and are thus mostly at very different stages. Consequently teachers can help pupils only on an individual basis; each pupil thus has limited contact-time with the teacher and is mostly left to his own resources. In comparison with Switzerland, our observations consistently indicated that average and below-average pupils in England achieved much lower standards in their practical work than comparable pupils in Switzerland. In addition, their general motivation dwindled as a result of their inadequately structured learning-experience and persistently disappointing rate of progress.

Swiss pupils generally made fairly straightforward but significant objects, graded according to their age, which were intended to be used by themselves or given away as presents, eg decorated metal key rings, wooden boxes (with sliding tops) made in the woodwork class and filled with assorted biscuits made in the home economics class, wooden blanket boxes (full-size, with metal hinges, carrying handles and locks), fashionable pieces of clothing; the plans and costings for a mini-billiard table shown in figure 1 give a not unfair

[55] NC Technology, pp.7, 15.
[56] HMI Report, para. 18.

impression of the average kind of work done by 14 year-olds. Knowing that these objects were to be used provided Swiss pupils with an incentive to achieve a good quality of finish. The standard of complexity and finish of objects produced by 14-15 year-old Swiss *Realschule* pupils were judged by English craftwork teachers accompanying our visits to be generally comparable to higher grades (A-C) in the former single-craft subjects at CSE and O-level.

When we were shown what pupils had done as part of their practical work in English classes, teachers often proudly produced, not artefacts, but pupils' 'design folders' this illustrates the extent to which practical 'making' had become marginalised. The artefacts pupils produced - if they reached that stage - were usually models or toys, eg model aeroplanes, model conservatories, toy boats. They were often a thing of the past as soon as they were finished, at best to be put in the classroom cupboard in case they needed to be assessed by GCSE moderators. The proportion of marks given to practical work at GCSE, as against the 'design folder' work, was often under a fifth; English pupils were thus not provided with strong incentives to achieve high quality of finish. Exceptionally good examples of practical work were sometimes on display in the entrance halls of English schools - but these had been made by exceptionally good pupils, and cannot be taken as typical. Examples observed in classrooms by typical English pupils included: crudely decorated cardboard boxes which were about to fall apart; a rough wooden train which fell to pieces when moved; a 'completed' electric table lamp which had not been wired up; a small woven piece of cloth which had to be done again because the pupil had not tied up the ends of the threads.

Work habits

In addition to providing Swiss pupils with specific skills, practical subjects are regarded both by Swiss employers and by Swiss teachers as serving wider-ranging educational functions.[57] First, and most

[57] The views expressed here on 'good work habits' attempt to summarise - primarily for the benefit of our English readers - what seem to us to be essential and important differences in attitudes towards practical subjects in schools in the two countries. We were particularly influenced by the differences in employers' views in the two countries. So much is widely taken for granted in Switzerland about the need to educate young people in school in 'good work habits' that they are often surprised that it is worth putting these matters into explicit words (for a fuller treatment, see Bierhoff and Prais, *op. cit.*, pp.61-2). That Swiss schools put more emphasis on the 'formation of character', while German schools concentrated on 'instruction', was noted 150 years ago by Kay-Shuttleworth (v. fn. 2 above, and G Howson, *A History of Mathematics Education in England* (Cambridge, 1982), p. 107.

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important, practical work raises the standards of what is called *Arbeitscharakter* - which might be translated as 'general good work-habits' - widely described as consisting of 'core-skills' (*Schlüsselqualifikationen*) such as perseverance, reliability, care, patience, and precision. When employers select school-leavers as potential trainees these characteristics are often given equal weight with academic qualifications. Pupils from *Realschulen*, as a result of their intensive schooling in practical subjects, are regarded by Swiss employers as having acquired particularly important advantages in respect of work habits which serve them well in mastering more complex tasks at work.

Secondly, Swiss *Realschule* teachers regard practical subjects as particularly valuable - perhaps even indispensable - in keeping below-average pupils motivated so that they persevere with their academic studies. The sense of achievement that such pupils gain from their practical work, and the change in style of learning from academic subjects, help to raise their general motivation at school. The levels of truancy of older pupils often found in English schools (especially inner-city schools) are unknown in Switzerland.

Thirdly, Swiss pupils acquire general learning skills of a sort that are relevant in subsequent employment: they learn how to respond effectively to corrections in applied contexts, to put them into practice, and to work at a pace appropriate to the task in hand. At British secondary schools, on the other hand, pupils are more often expected to 'discover for themselves', and 'work at their own pace'; the difficulty is that employers cannot afford such time-consuming methods in their training schemes. British school-leavers who go on to an apprenticeship thus often find undue difficulties in adapting to a way of learning and to a pace of activity for which they have not been well prepared at school.

Revised curriculum in England, 1994

The original objectives associated with the teaching of Technology in Britain were broad and diffuse; they ranged from 'develop[ing] entrepreneurial skills in the youngest of children', and 'breaking down the academic and vocational divide [in] British education', to 'rekindl[ing] the huge creative power that characterised the first British industrial revolution'.[58] Indeed, so nebulous and all-embracing were

[58] D Graham with D Tytler, *A Lesson for Us All*, (Routledge, 1993), p. 53-54 [Graham was chairman and chief executive of the National Curriculum Council]; J Eggleston, Editorial, *Design and Technology Teaching* (1991, no. 3), p. 4.

the original objectives that some of the originators of this new subject favoured a cross-curricular approach: 'it would not be necessary to do any of the old craft subjects at all and ... technology could be delivered in history or geography, maths or science'.[59]

The expressed key concern of the (Dearing) proposals for the revision of the National Curriculum in Technology issued in May 1994 was to 'simplify and clarify the requirements of the [1990] Order';[60] there was no general intention to bring the requirements more into line with accepted practice in other countries. The new draft Order issued at the end of 1994 similarly did not question the original principles. It is however worth noticing that the (Dearing) proposals wanted pupils to 'be taught ... to develop their *manual dexterity* and refine their *craft skills*'; this spark of hope was soon quenched - no similar statement is to be found in the new Order.[61]

Nevertheless, there has been an important relaxation for those schools wishing to follow a different approach. For 14-16 year-olds (Key Stage 4) it is now legally possible to fulfil the 'minimum mandatory requirements' under the National Curriculum through a 'short course' (intended to absorb half of the time of a full course, say, 5 per cent of total curriculum time or two school-periods a week). In principle this should leave more school time available for practical work leading to an additional whole GCSE qualification in a single-craft subject (eg metalwork). Such courses, and associated examinations, will be available through the Welsh GCSE board (Wales, curiously enough, has been exempted entirely from NC requirements in Technology at Key Stage 4); alternatively, a short course in Technology might be combined with a short course in, say, metalcraft.

However, other significant changes in the 1994 Order will not bring English teaching practice in this field closer to that of Switzerland (nor other Continental countries, such as the Netherlands and Germany). Under the previous Order very broad areas were to be covered by each pupil in the final two years of compulsory schooling; for example, pupils were required to work in at least three out of four categories of specified materials (textiles, graphic media, construction materials, food), and to work to four Attainment Targets ('identifying needs and opportunities' 'generating a design', 'planning and making', 'evaluating').[62] In addition to the wide range of

[59] Graham and Tytler, *op. cit.*, p. 56.
[60] Draft Proposals, May 1994, p. iii.
[61] *Ibid.*, pp.8, 12.
[62] The requirements varied: some NC documents required four types of material, others referred to a choice out of five - the fifth being 'information' (*sic*!); see the Appendix to our 1993 article (p.69).

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more 'traditional' materials specified in the previous Order, pupils are required under the new Order to work with electrical and mechanical components, construction kits, control systems and structures; they are also required to 'investigate, disassemble and evaluate a wide range of products and applications to learn how they function'; and pupils' projects at Key Stage 4 'should require activity related to industrial practices and the application of systems and control'. The subject-areas to be studied ('touched on' is probably more realistic) under the new Order are thus even broader than previously.[53]

The number of Attainment Targets has been reduced under the new Order from the original four to two: 'designing' and 'making'. This alteration, however, is largely nominal. The 'making skills' to be acquired by pupils as envisaged under the new Order include remarkably ambitious and wide-ranging activities; for example: pupils should be taught 'to simulate production and assembly lines', 'how products are manufactured in quantity including the application of quality control and quality assurance', 'to produce and use detailed working schedules that will achieve the desired objectives, setting realistic deadlines for the various stages of manufacture, identifying critical points in the making process and providing alternatives to possible problems', 'to evaluate the quality of products and to devise modifications that would improve their performance', and so on. None of this bears any resemblance to the modest way 'making' is understood in the teaching of practical subjects in Swiss secondary schools. In addition, pupils in England will still be required to 'generate ideas', 'identify appropriate sources of information', 'generate design proposals', 'develop ... design briefs and detailed specifications', 'devise ... test procedures to check the quality of their work,' 'develop criteria for their design to guide thinking', etc.[54] Many of the previous requirements are thus merely presented under different sub-headings in the new Order; and cerebral (pseudo-cerebral?) activities will continue to take up the majority of time in Technology

[53] 'One or more focus areas' are permitted under the new Order; but it has still to be clarified how this is to be implemented in practice (for example, can 90 per cent of the time be devoted to metalwork and 10 per cent to the remainder?).

[54] The arbitrariness of the NC allocation of tasks to the two Attainment targets is evident from the overlap; eg 'to be *flexible* in their working practices, in order to respond to changing circumstances and new opportunities' is listed as a Designing Skill: while 'to be *adaptable* in their working practices, in order to respond to changing circumstances and new opportunities is listed as a Making Skill (see pp. 10-11 of the 1994 draft revised curriculum on *Design Technology*).

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lessons.

In Switzerland the topics to be covered by pupils in their practical work has also been increased in recent years - but by no means to the same extent. Under the curriculum introduced in Zürich in 1992, pupils irrespective of gender all carry out work in wood, metal, textiles and home economics in the first two years of secondary schooling, at ages 13-14; in the final year, at age 15, they are permitted to specialise.[65] There is now no obligatory division by gender in the choice of subjects as there was in previous years. Standards of work in specialised areas appeared to our observers to have dropped somewhat since the broadening in the number of materials under the new curriculum. This may prove to be a disadvantage particularly for *Realschule* pupils; it is too early to say whether it will be outweighed by the greater breadth of materials covered. Notwithstanding this change, Swiss lessons in practical subjects continue to be focused on the acquisition and refinement of practical craft skills.

RESUME AND IMPLICATIONS

The preceding pages have described how Swiss schools provide their pupils with distinctly higher attainments than British schools in the three important subject areas that we have compared: mathematics, science and practical subjects (or 'Technology'). The standards observed in these subjects in Switzerland were not in any way beyond those attained by *some* pupils in English schools; but significantly greater proportions of Swiss than English pupils reached good standards. Our classroom observations consistently confirmed the IAEP findings of exceptionally good attainments by Swiss pupils in the lowest quarter or lowest third of the attainment range; in mathematics, Swiss pupils in this section of the attainment range seemed to be ahead by a year or two even of average English pupils. This provided Swiss school-leavers with a much better foundation for skilled vocational training than available to corresponding school-leavers in England.

Some common differences between the countries in the teaching of these three subjects can perhaps be identified in teaching styles

[65] As mentioned, *Gymnasium* are exempted from these requirements; what is said here thus applies only to about 90 per cent of all pupils. Additional voluntary classes were available in some schools we visited in pottery and photography. Technical drawing was obligatory for boys till 1992 throughout their three years at *Realschule*, but is now an optional subject available only in the third year.

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and syllabus content. In mathematics, as we have seen, there is no open-ended investigative work by pupils in Switzerland; in science, there is more demonstration by teachers of experiments related to basic scientific laws, and less time devoted to pupils' individual experimental investigations; in practical subjects, pupils spend almost all their lesson-time each making something to a common given design, and very little time is devoted to individual designing. In Britain, individualistic 'investigative', 'discovery' and 'problem-solving' methods are all-pervasive, encouraging distinct work by each pupil: these methods are based on the notion that the teacher is to co-operate with individual pupils, or small groups of pupils, so that learning activities develop out of discussion between them. In practice, with 20-30 children in a class, insufficient time is available for a teacher to deal adequately with pupils on a one-to-one basis, or even in small groups. Pupils are thus to a great extent left to their own resources, and too much of pupils' time is not spent in effectively learning.

In Switzerland the emphasis on pupils' active involvement in the learning process - which can be traced to the Swiss educationist Pestalozzi - is not lower than in England; but the way it is applied is very different. The Swiss teacher spends a considerably greater proportion of lesson-time in *guiding* the learning of his pupils using a well-developed style of whole-class teaching with considerable question-and-answer interaction. The narrower range of attainment within each level of Swiss secondary schooling enables a Swiss teacher to fix on a realistic set of teaching objectives, and a suitable pace of teaching, to stimulate virtually all pupils in his/her class. While acknowledging the individuality of each child, the Swiss teacher builds to a greater extent on what pupils in the class have in common, and he works hard to take them forward together. The British approach, on the other hand, builds on existing differences amongst pupils and, in effect, enhances those differences; the teaching of an English class as a whole thus becomes increasingly difficult as pupils become older.

In short, a prime difference between the countries, common to those three subjects, relates to the greater role in Switzerland of whole-class teaching. A second common difference can perhaps be identified in the greater Swiss emphasis on agreed basics - a basic mathematics literacy, a basic scientific literacy, and proficiency in basic practical skills. In mathematics, for example, there is a greater concentration in Switzerland on basic arithmetic and areas; and in practical subjects there is greater emphasis on learning the use of tools

and properties of materials within a specialised range (eg woodwork). There is a wider acceptance in Switzerland that such basics need to be mastered by most pupils; in Britain the National Curriculum documentation is broader and more imaginative (to put it at its best), without managing to convey in any precise understandable way the essential core of each subject.[66]

There is a noticeably greater evenness of Swiss pupils' attainments on entry to secondary schooling which results partly from the excellence of Swiss primary school teachers, and partly from the organisational mechanisms which support them. It would be beyond the aims of the present study to go in any depth into the distinctive features of Swiss primary schooling; but perhaps it is not out of place to mention here - since the same underlying principle governs their secondary schooling - that great attention is given to not putting a child into a class to which he/she is not suited.[67] Swiss primary schools are based on mixed-ability teaching, but the mix is limited by a greater reliance on the criterion: is the child 'ready for school'? This involves greater flexibility in ages on either side of a prescribed twelve-month range of birthdates than is followed in England, in order to ensure the child is ready in social, psychological and intellectual terms. Subsequent class-repetition is consequently rare, and amounts to hardly more than one child a year per two classes; nevertheless, class-repetition remains an ultimate sanction, and provides pupils, parents and teachers with a sense of immediacy and realism with regard to schooling attainments for which no counterpart is available in English schools.

It is worth assessing consequences of the overall differences in school attainments in mathematics and science - which are easier to quantify than attainments in practical subjects - in terms of the proportions of school-leavers ready for vocational training. Successful entry to craft apprenticeship courses in England generally requires

[66] A recent survey of teachers on the implementation of the National Curriculum in mathematics reported that some teachers had 'difficulty in interpreting the statements [the syllabus requirements] into classroom practice. These statements are not just ones that are hard to give meaning to at a particular level, but are also statements that teachers do not understand.' Parents must be expected to have had even greater difficulties! See M Brown, D Johnson, M Askew, A Millet, *Evaluation of the Implementation of National Curriculum Mathematics at Key Stages 1, 2 and 3* (SCAA, 1993), Summary Report, p. 6.

[67] A comparative study of the teaching of mathematics in primary schools in England and on the Continent, including Switzerland, has recently been started by the Institute in co-operation with the London Borough of Barking and Dagenham, and with the support of the Gatsby Charitable Foundation.

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that a school-leaver attain a pass at GCSE at least at grade D in three core subjects - English, mathematics and science (there is of course some variation; for example, a grade C in mathematics is usually required for electrical engineering craftsmen, while a grade E in that subject may be acceptable for building courses). Only the top 29 per cent of pupils in England were reported as having attained grade C or better in those three subjects in 1993; about another 10 per cent attained grade D, giving a potential total of some 40 per cent.[68] If the distributions of scores recorded by the IAEP surveys applied also at school-leaving ages, the scores attained by the top 40 per cent in England would be attained by as many as the top 65-70 per cent in Switzerland; after creaming off the top 20 per cent in each country for university or other full-time higher education (30 per cent is planned for England), we are left with hardly some 20 per cent in England who would be capable of entering an apprenticeship compared with 45-50 per cent in Switzerland. It is in this way that differences in secondary schooling attainments effect ultimate differences in the extent of vocational competence.

In concluding it is perhaps as well to reiterate that it would be mistaken to suppose that the detailed distinctive features of Swiss schooling could immediately be transferred to English schools without modification. The correct approach, rather, is to recognise the essential similarity of ultimate objectives that guides both countries' schooling systems, and to consider carefully which methods of attaining those objectives serve most readily as a model for the next steps forward.

[68] DfE *Statistical Bulletin* 7/94, table 5, for A-C; estimates for grade D were interpolated from table 7.

Appendix

A SWISS EXPERIMENT IN COMPREHENSIVE SCHOOLING

As in other countries, there have been pressures in Switzerland to establish comprehensive secondary schools catering for a broad range of abilities. But the Swiss have moved slowly and cautiously. In the Canton of Zürich just over a dozen schools in a few school-districts have moved experimentally to a comprehensive form since the end of the 1970s; they now (1994) account for about a tenth of all secondary pupils in the Canton. During the 1980s the mathematical attainments of pupils in these experimental schools were compared with a matched sample of schools in comparable districts which followed the traditional selective pattern. The results of these comparisons are of wider interest and are summarised here for the benefit of English readers; the discussion has been taken a little further than in the original Swiss report, with somewhat different implications.[69]

The comparisons were based on a total of 800 secondary pupils, consisting of two age-cohorts who had finished primary schooling in the summers of 1984 and 1985 respectively; the pupils were tested at the end of their primary school (at about age 12), and then again after two years in their various secondary schools (at about age 14).

The traditional selective secondary schooling system in Zurich - as explained in chapter 3 above - consists of four levels of schooling which we may here call simply A, B, C and D. The top level A (the *Gymnasium*, accounting for just over a tenth of all pupils) was retained as a separate type of school; it was only the lower three levels B, C and D - accounting for nearly nine-tenths of all pupils - which were combined into a new 'experimental' comprehensive type of school which became known as AVO.[70] Each AVO school was divided into two ability-streams for almost all subjects; the exceptions were mathematics and the first foreign language - French - for which pupils were divided into three 'sets' (*Niveaugruppen*) on the basis of their attainments in each subject. For mathematics there is therefore a degree of correspondence between the old B,C,D selective schools and the three sets in the new AVO comprehensive school. It was the attainments of pupils in these three paired levels that formed the basis of the Swiss comparisons. Different mathematics syllabuses and textbooks applied to each of the three levels in both the old and new systems: but much the same syllabuses

[69] The account given here is based on the original report in German by S Rosenberg, *Leistungsuntersuchung in Mathematik: Vergleich zwischen AVO und dreigliedriger Oberstufe während den Schuljahren 1983/84 bis 1986/87* (Pestalozzianum Zürich, report no. 27, duplicated, 1987); we are grateful to Frau Rosenberg and her colleagues for discussing the issues with us. Similar and even more detailed comparisons were carried out for comprehensive and selective schools in certain German *Länder* at about that time, eg by K Aurin, B Schwarz and R-D Thiel, *Gegliedertes Schulsystem und Gesamtschule: Vergleichsuntersuchung des Landes Baden-Württemberg* (Ministerium für Kultur und Sport, Stuttgart, 1986, v. esp. the concluding chapter by Professor Aurin, vol. II, p. 346), and several articles in the *Zeitschrift für Pädagogik*, October 1980, on Nordrhein-Westfalen and Austria. We are not aware of any similar comparisons for Britain.

[70] Short for *Abteilungsübergreifende Versuche an der Oberstufe*.

were used at corresponding levels in the two systems. Mathematics tests were accordingly designed by teachers for each of the three levels, and administered to pupils in both systems.

The results are summarised in table 1 below. They show no difference in attainments at level C (the *Realschule*), where pupils in both the old and new types of school obtained an average score of 53 per cent (see right-hand side of table). But at the upper and lower levels - B and D - pupils in comprehensive schools did not do as well as in the traditional selective schools.

Low-attaining pupils

These differences need to be discussed in more detail, taking into account the individual organisational features of some of the sample schools. Let us begin with the lowest level of attainment, where pupils of the traditional selective system (*Oberschulen*) obtained an average score of 34 per cent while pupils in the comparable level of the comprehensive system on the same test averaged a score of only 27 per cent. This probably does not express the full extent of the gap between the systems, since the set of low-attaining pupils in the comprehensive system accounted for 16 per cent of all pupils, compared with only 9 per cent of pupils in the selective system (see left-hand side of table 1). Because of its greater breadth, the comprehensive low set should be expected to include pupils who are higher in their *general* ability than were included in the selective stream; there is a possible offsetting factor in that, in terms of *mathematical* ability, the comprehensive schools might have been more effective in selecting pupils who were weak in that subject alone, rather than in all subjects taken together (the criterion for pupils in the selective system). However, this offset is unlikely to be large since mathematical and general attainments - while not identical - have a fairly strong positive correlation. On the whole therefore, we should still expect the wider band of comprehensive pupils would have done better, and not worse, than the corresponding selective pupils.

If we were to base our comparisons - as we should - on the *same proportion* of pupils in both systems, we would need to know the average score of the lowest 9 per cent of pupils in the comprehensive system (out of the 16 per cent actually in that set). That might reduce the average score for comprehensive pupils from the recorded 27 per cent to under 20 per cent.[7] The true gap between the systems at this lower end of the attainment range is thus between a score of 34 per cent for selective schools an approximate score of under 20 per cent for the comprehensive schools.

The estimated gap between the systems would be reduced if we omit an unusual low-attaining class in one of the comprehensive schools (school G, class

[7] The true average score for the lowest 9 per cent could have been obtained from the original records (but they are no longer available). For the present purposes we made estimates of the original frequency distributions based on the published information for each school of the minimum and maximum scores, together with averages and standard deviations (Rosenberg, table 31). Removing the top slice (between the 9th and 16th parameters) left an average score of only 14 for the lowest 9 per cent of pupils; to allow for imperfect correlation between general and mathematical attainments we have roughly raised the estimate average score to 'under 20 per cent' in the text above.

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e2). This school integrated Special pupils (*Sonderklässler*) in one of the two years of these comparisons; the lowest mathematical set was described as having included some ('*einige*') of these pupils, leading to an average score for that class a mere 3 per cent.[72] The class consisted of 7 pupils; though only *some* were Special pupils, it seems that other pupils in that class also had made very little progress. Omitting that class in its entirety from the comparisons would raise the average score in that lowest comprehensive stream from the recorded 27 per cent to 30 per cent; the estimated score for the lowest 9 per cent of comprehensive pupils - for comparison with the corresponding percentage in the selective schools - might rise from the 20 per cent suggested above to, say, 23 per cent. That still leaves a substantial contrast with the score of 34 per cent recorded for the average selective school at that level (the *Oberschule*).

Table A1. Mathematical attainments of samples of 14 year-old pupils in comprehensive and selective schools, Switzerland 1986 and 1987

Set/level[a]	Percentage of pupils		Average scores at age 14[b]	
	Comprehensive sample	Selective sample	Comprehensive sample	Selective sample
B Sekundarschule	53[c]	55	56	63
C Realschule	31	36	53	53
D Oberschule	16	9	27[d]	34
	100	100		

Source Rosenberg, *op. cit.* (see main text fn. 69).

Notes

a Name of level in selective system; different tests were applied to each level.

b The original test-scores were based on a varying numbers of questions and points (group A: 24; B: 22; C: 19); they have here all been converted into percentages.

c One of the larger comprehensive schools (P) was divided in four ability-levels; the second level 'BC' can be considered as roughly equivalent to the lower part of what, in other schools, formed level B. On that basis, level B (excluding BC) accounted for 38 per cent of all pupils in the comprehensive sample, and attained an average score of 64 per cent; and level BC accounted for 15 per cent of all pupils in the comprehensive sample, and attained an average score of only 35 per cent (all measured on the same test; see text).

d If school G is excluded, the average rises to 30 per cent (see text).

As emphasized in the original report by Rosenberg, the two samples of schools were matched in terms of parental occupation, national origin and language. Parents in both types of Swiss school-districts were not offered a *choice* between comprehensive and selective schools (as usual in those parts of Germany where comprehensive schools are available): pupils were directed to a local school on the basis of official policy in each district. There should therefore be no reason to suspect that, as a result of 'creaming', pupils of lower calibre went to comprehen-

[72] See pp. 9 and 23-24 of the original report.

sive as compared with selective schools.[73] It therefore seems that there was a relative deterioration amongst low-achieving pupils who happened to be living in districts where they were required to attend comprehensive secondary schools.

It is always possible that the tests given to pupils at this level was not well-designed to display the true attainments of such pupils, or that there were changes in teaching materials or teaching styles which needed more time to settle down effectively.[74] A repeat of such comparisons seems desirable, especially since several more years have now elapsed during which the new system has been able to settle down.

High-attaining pupils

For the upper set an analogous contrast was observed between the systems: pupils at level B in selective schools (*Sekundarschulen*) attained an average score of 63 per cent, compared with 56 per cent in the top sets in the comprehensive schools. These comparisons were based on very similar proportions of all pupils in the two systems (55 and 53 per cent respectively).

There is again an organisational difference which slightly muddies the waters: one of the comprehensive schools (school P) divided pupils for mathematics into four sets instead of the usual three; the top two sets both followed the same syllabus as for the comparable top selective schools, but the lower of the two sets adopted more modest targets within that syllabus. If that lower set is omitted, then the average score for the comprehensive sample rises to 64 per cent, a shade above the selective schools' average score of 63 per cent. This does not however seem a legitimate omission, since it would leave only 38 per cent of all pupils in the upper stream of the comprehensive sample compared with 55 per cent of

[73] The pre-tests in mathematics administered in primary schools at age 12 unfortunately do not cast conclusive light on the relative calibre of stream-D pupils in the two systems. As published (Rosenberg, p.12, tables 10 and 11), it seems that the initial attainments of those pupils who went on to comprehensive schools were of slightly *higher* ability than those who went to the selective (published average scores, respectively, of 5.5 and 4.9, out of 19 - corresponding to 28 and 25 per cent); but there are two reasons for not accepting these average scores at face value. First, there seem to have been problems with the administration (or recording) of the pre-tests for this stream: 14 pupils are recorded as moving to the selective *Oberschule* on the pre-test, but 30 pupils are recorded as taking the full test two years later (there is also a discrepancy - but one that is small enough to be ignored here - in the recorded numbers of pupils at the two ages in the comprehensive school, shown as 58 pupils at the pre-test and 64 at the higher age). Possibly some pupils were not tested at age 12; or possibly (but unlikely?) there were subsequent substantial movements in the selective system from higher to lower streams. In any event, the discrepancy in pupil numbers is such that it is difficult to take the pre-test for the *Oberschule* as giving adequately reliable information for our purposes. A second reason is that even the full number of 30 pupils in the *Oberschule* represents a smaller fraction of all pupils in the selective system than the 64 pupils in the lowest stream of the comprehensive system; as above, this would lead to an expectation of higher initial average scores for the comprehensive stream. These uncertainties in total are too great to warrant any worthwhile inference.

[74] Rosenberg (p.26) reported identical training of teachers in the two systems and similar didactic models, but listed special AVO textbooks in her bibliography.

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pupils in the selective sample.

We may therefore phrase the results of the comparisons for the top group of pupils in one of two ways: we may compare either roughly the same *proportion* of top pupils in the two systems (that is 53-55 per cent of all pupils in each system), in which case we find the average score of comprehensive pupils is rather lower than of pupils in selective schools (a score of 56 compared with 63 per cent); or we may take as our standard the average *score* of 63 per cent reached by the top 55 per cent of selective school pupils, in which case we find that only 38 per cent of comprehensive pupils - a third of pupils fewer than in the selective system - were able to attain that standard.

Reasons for deterioration

The deterioration of attainments in Swiss comprehensive schools at the upper and lower ends of the range has taken place even though only very further limited changes were made: in contrast to British comprehensive schools, in Swiss comprehensive schools electronic calculators are not routinely used in mathematics lessons; a stronger emphasis in mathematics teaching remains on basic arithmetical operations; and there is no mixed-ability teaching of mathematics. How, then, did the deterioration take place?

An earlier Swiss enquiry, though based on a more limited sample, offered some suggestions.[5] First, there was a third *less homework* in comprehensive schools; secondly, lessons in comprehensive schools were *interrupted* to a greater extent by socialising projects - weeks devoted to camps, outings and other special projects; thirdly, *motivation* was lower. The last was noticed especially amongst pupils just below the top: they regarded themselves as doing well compared with the majority who were below them in their comprehensive school, whereas their peers in selective *Sekundarschulen* felt a greater incentive to match others in their class. In relation to pupils of lower academic attainments, it was frequently mentioned on our visits to Swiss *Realschulen* that such pupils are more strongly motivated as a result of having a single form-teacher for most subjects, who understands better their relative strengths and weaknesses; while in AVO comprehensive schools each pupil is taught by a greater number of teachers. Further, *Realschule* pupils particularly benefit from having their own desks in their own classroom, surrounded by familiar friends; in AVO more time is spent in wandering from one classroom to another, with a fresh taking of the attendance register to check for truants, and time required for 'settling down' to work again.The *Realschule* system of a single form-teacher also permits the teacher to finish a topic, even if it means over-running the normal school time-table.It is reassuring to learn that steps to *reduce* the number of teachers involved in teaching each class in comprehensive schools (*'um die Lehrerwechsel zu begrenzen'*) have recently

[5] R Tobler, *Evaluation der Stammklassen-Niveau-Organisation 2: Leistungsaspekt am Beispiel der Mathematik* (AVO report no. 8, Zürich, 1982); esp. pp. 51 *et seq.* and 62-44.

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been considered."[76]

Great emphasis is placed by the Swiss researchers on the social advantages resulting from pupils of all abilities being educated in the same building, and from being able to mix with one another as a result of moving to different sets according to their attainments. These social advantages are not negligible; it needs however to be recognised that there is a cost in terms of attainments - even of that very group of pupils which it is desired to help most. Changing to a higher or lower set for mathematics obviously takes place more easily and more frequently in a comprehensive than in a selective system: while this may be an advantage for the pupil who moves and in relation to that subject, one must not discount the wider psychologically disruptive effects on those pupils who benefit from the opportunity of being in a stable environment at school.

Statistical aspects

Analyses of variance in the original Swiss report showed statistically highly significant differences according to school-system for the upper ability set B (P<0.1%), no statistically significant difference for set C, and a moderately significant difference (P=7%) for the lowest set D. These analyses included school, class and gender as additional factors, but made no allowance for the different slices of the ability-range compared; this last factor, as explained above, is an important element in assessing these comparisons. Pre-test attainments in mathematics at age 12 were not brought into their statistical analyses by the Swiss researchers; had that been done, by regarding the pre-test score as a determining variable in a regression analysis (or as part of an equivalent analysis of covariance), better - but not necessarily different-estimates might have been obtained for the average gap in attainments between the school-systems as a whole, and for the three component ability-sets."[77]

It is true, as the Swiss researchers emphasized, that many factors affect schooling attainments apart from those taken into account in their statistical analysis, as is shown by the large residual variation amongst schools within each system; nevertheless, insofar as their analysis was concerned with the observed difference between the systems in pupils' attainments in mathematics, it has to be concluded that the selective system in Zurich has demonstrated on average a statistically significant advantage over the comprehensive system."[78]

[76] *Schul-Statistik*, 1/1991, p. 2.

[77] Such covariance analyses have been carried out, for example, in the studies for Baden-Württemberg reported by Aurin *et al.*,*op.cit.*,pp. 350 *et seq.*Our own technical preference would be to employ multiple regression analyses to estimate the magnitude of the average difference in pupils' attainments, and not simply its *statistical significance* which emerges from an Analysis of Variance.

[78] It is a fundamental virtue of statistical analyses of this type that they enable the researcher to identify significant factors despite substantial 'background noise' generated by other factors; this point does not always seem to have been appreciated by the Swiss researchers.

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